

3D Printing In Healthcare

Caleb Branch

Follow this and additional works at: <http://fisherpub.sjfc.edu/ur>

 Part of the [Bioimaging and Biomedical Optics Commons](#), [Biomedical Devices and Instrumentation Commons](#), and the [Biotechnology Commons](#)

[How has open access to Fisher Digital Publications benefited you?](#)

Recommended Citation

Branch, Caleb. "3D Printing In Healthcare." *The Review: A Journal of Undergraduate Student Research* 16 (2015): 1-4. Web. [date of access]. <<http://fisherpub.sjfc.edu/ur/vol16/iss1/3>>.

This document is posted at <http://fisherpub.sjfc.edu/ur/vol16/iss1/3> and is brought to you for free and open access by Fisher Digital Publications at St. John Fisher College. For more information, please contact fisherpub@sjfc.edu.

3D Printing In Healthcare

Abstract

Technology is everywhere. Technology surrounds every aspect of 21st century life. It is in the cell phones we use, the cars we drive, and even the food we eat. A large portion of modern technology used is taken for granted and overlooked. Despite this, some technology fields continue to grow. Biomedical engineering, specifically 3D printing's applications to healthcare, has been often overlooked until. Regardless of its status in the mainstream, 3D printing is prosperous in healthcare and its future looks bright. This piece analyzes 3D printing in healthcare. It hones in on the finer details of each specific topic, including how 3D printing currently works, its limitations, current and future applications.

Keywords

3-D printing, biomedical engineering, medical imaging

3D Printing In Healthcare

Caleb Branch

Abstract

Technology is everywhere. Technology surrounds every aspect of 21st century life. It is in the cell phones we use, the cars we drive, and even the food we eat. A large portion of modern technology used is taken for granted and overlooked. Despite this, some technology fields continue to grow. Biomedical engineering, specifically 3D printing's applications to healthcare, has been often overlooked until. Regardless of its status in the mainstream, 3D printing is prosperous in healthcare and its future looks bright. This piece analyzes 3D printing in healthcare. It hones in on the finer details of each specific topic, including how 3D printing currently works, its limitations, current and future applications.

Introduction

The goal of biomedical engineering is to close the gap between engineering and healthcare. It combines the problem solving and calculation oriented side of engineering with medicine's viewpoint of the human body, its workings, and solutions to scenarios, to create an entire different branch of medicine and technology. Within this field, there are many disciplines, with different focuses on how to fix each problem within an abnormally functioning human body. The main focus of this paper, 3D printing, is one of these disciplines of biomedical engineering. Three dimensional (3D) printing is a form of additive manufacturing; "where a stack of layers is printed one by one, ultimately forming the desired object" (Houtilainen, Paloheimo, Salmi, Paloheimo, Björkstrand, Tuomi, . . . Mäkitie, 2014, p. 78). In a nonmedical discipline this can be as simple as creating children's toys, or as complex as forming jet

engine turbines; the applications are endless. Medically speaking, there are many uses for this technology, which are evolving every day in locations as close as Cornell University. According to Miller (2014), the shifting trend of 3D printing in biomedical engineering occurred from the need for biological processes to be involved into implanted pieces. Cells ultimately dictate body chemistry, and what would be a better replacement for malfunctioning cells in the human body than functioning cells? The answer to this question is nothing. In the following paragraphs, 3D printing will be further broken down into how it currently works, its applications, and what its future holds.

Basic Concepts of 3D Printing

The medically minded may understand 3D printing and additive manufacturing better by drawing parallels between the former and computerized tomography, otherwise known as a CT scan. "A computed tomography (CT) scan is an imaging method that uses x-rays to create pictures of cross-sections of the body" (U.S. National Library of Medicine [NLM], 2014). Essentially, consecutive x-ray images are stacked on top of each other to create 3D images of the human body.

Houtilainen et al. (2014) stated:

Consider a CT scan, which consists of multiple planar slices: in a certain way, AM (additive manufacturing) might be called its reverse process where digitized images are brought back to the physical world as metal, plastic, ceramic, or composite parts regardless of the complexity of their

shape. Most AM processes have layer thicknesses far thinner than slice thicknesses of primary medical imaging methods, thus the radiology step of the production process is crucial for model accuracy (p. 78).

Houtilainen et al. (2014) compared 3D printing and CT scans very effectively by saying that 3D printing is essentially the opposite of CT scans; CT scans take a whole object and break it down into layers of images in a computer, whereas 3D printing takes layers of images in a computer and creates an object from them. With these combined concepts, the need for enhanced computer imaging is clear in the last sentence; 3D printing is capable of creating a level of finesse and detail in its layers that current medical imaging is not capable of delivering.

Limitations of 3D Printing

A foundation of 3D printing in healthcare is creating needed body parts from images derived from the individual in need. Each and every individual's body is as unique as their personality. This uniqueness creates a need for replacement body parts to be individualized, and nearly identical to what they are replacing. Currently, however, there are only two mainstream applications for medical imagery, for diagnostic purposes and for preoperative purposes. Houtilainen et al. (2014) describe the former as a more qualitative and less focused image, whereas the latter needs more accurate images in order to plan out a procedure. Diagnostic imaging essentially identifies what is wrong with a person; it is preliminary. Preoperative imaging includes more details. It guides surgeons and other doctors in the direction needed to approach a procedure. They later go on to describe increased imaging capacity for 3D printing by stating

“[The] Need for anatomical accuracy and an ability to create full 3D models” (Houtilainen et al., 2014, p. 79). With an increased imaging technology, details of 3D printed medical applications would become greater. This increased level of detail would facilitate the ability to create even more anatomically correct 3D printed body parts. The lack of this increased detail however, greatly impedes on current 3D printing technologies in healthcare.

The greatest limitation of 3D printing currently is the inability to create specific details down to the cell level. Imagery, as mentioned before, is a huge process that impedes 3D printing technology. If imagery lacks the ability to create fine detail as mentioned before, how can we expect current technology to go even further and create detail at a cellular level? The answer to this is we cannot rely on existing technology. Currently, the largest road block to creating functioning organs, which encompasses details at the cellular level, is recreating vasculature of body parts. Vasculature is all of the different blood vessels of the body, including the very microscopically detailed capillaries. Creating capillaries makes vasculature detail tricky. Capillaries filter single red blood cells at a time; so unless we have imagery that gets down to the single cell level, recreating exact vasculature of organs will be impossible. According to Miller (2014), “Organs like the lung, heart, brain, kidney, and liver are pervaded by incredibly elegant yet frighteningly complex vascular networks (carrying air, lymph, blood, urine, and bile) leaving us without a clear path toward physical recapitulation of these tissues in the laboratory” (p.1). This results in us being unable to recreate the fine details of organs, which are essential to normal functioning and biological processes. It is like photocopying an image, the details are never as great as the original. According to

Chastain (2014), “even a simpler organ has a lot of vasculature. You have to be able to have very, very thin capillaries. We’re just not at the point where we can make those kinds of structures.” (p.16). Chastain mirrors Miller’s viewpoint that we just aren’t at the level where we can create exact details like vasculature. Once we get to this point of being able to recreate vasculature, it will essentially open Pandora’s Box as far as creating organs is concerned.

Current Medical Applications of 3D Printing

Although 3D printing isn’t as refined as experts would like it to be, applications are currently still available for 3D printing in healthcare. According to Kaur (2012), applications include hearing aids, jaw replacements, bones, crowns and bridges, limb replacement, and tooth caps. Hearing aids can be 3D printed to the exact size and shape of a person’s ear canals in order to create an exact and personalized fit. This outer shell that is created from a 3D printer can then have hearing aid inserted into it, making a completely one of a kind solution to hearing deficits. Bones can also be recreated to replicate a person’s original bone. The jaw bone is such an example, as we can now replace an entire jaw bone with artificially created materials. Plastic polymers are the main components of these bones, which is different than the surgical titanium approach that has been the tried and true typical approach to bone replacements. Prosthetics are also personally fit to the individual in order to create exact fitment. These prosthetics are customized in a variety of ways. For example, a prosthetic leg can be custom fit using 3D printing in many aspects. The leg can be adjusted based on height, width of leg being replaced, and most importantly, how the leg would be attached to person’s distal portion of what is left of their leg. Lastly, dentists can recreate

teeth that were once in an individual’s mouth to exact specifications. With these current applications of 3D printing in healthcare, the future looks bright.

The Future of 3D Printing in Healthcare

In the future, medical professionals will seek to create technologies that detail the vasculature of a person’s original organs. The ultimate goal is the replacement of faulty organs with real, live, fully functional versions. There are two different ways to approach the topic of reproducing vasculature. There is the placement of stem cells in a specific area and finding a way to get them to differentiate, or placing specific differentiated cells in a specific area, ready to function (Chastain 2014). Both approaches would require cells to be placed in specific locations. The former would require one to take undifferentiated cells, and, by a yet un-discovered process, make them differentiate to perform specific roles. To perform the latter, medical professionals would be faced with the challenge of placing specific cells, which are already differentiated, in specific places. These processes will both require an extraordinary amount of precision. Unfortunately, we are unable to be as precise as needed in order to create vasculature and detail because the imaging technology has yet to be developed. This will be the aim of 3D printing in the future, as this will result in the ability to create fully functioning organs which is the ultimate goal of 3D printing and biomedical engineering.

Conclusion

3D printing and additive manufacturing has been around since the dawn of computers. Despite this technology being around for so long, 3D printing’s applications in healthcare are in their infancy. Nevertheless, 3D printing currently offers many applications for healthcare.

With it being in its infancy but still offering many applications currently, the future for 3D printing is extremely promising. One day in the near future people will be walking around with organs inside them that were printed with a computer using their own cells, instead of transplanting organs from donors most likely at the end of their lives. Once the technology catches up with current ideas, healthcare will be forever changed.

References

- Chastain, A. (2014). If you print it, they will come. *Virginia Quarterly Review*, 90(4), 12-18.
- CT scan: MedlinePlus Medical Encyclopedia. (2012). *U.S. National Library of Medicine*. Retrieved from <http://www.nlm.nih.gov/medlineplus/ency/article/003330.htm>
- Houtilainen, E., Paloheimo, M., Salmi, M., Paloheimo, K., Björkstrand, R., Tuomi, J., . . . Mäkitie, A. (2014). Imaging requirements for medical applications of additive manufacturing. *Acta Radiologica*, 55(1), 78-85. Retrieved from <http://acr.sagepub.com/content/55/1/78#aff-1>
- Kaur, S. (2012). How is "internet of the 3d printed products" going to affect our lives? *Medknow Publications & Media Pvt. Ltd.*, 29(5), 360-364.
- Miller, J. S. (2014). The billion cell construct: Will three-dimensional printing get us there?. *Plos Biology*, 12(6), 1-9.